JOURNAL

OF THE

New York Entomological Society

Vol. XXXVIII March, 1930 No. 1

HOW MANY SPECIES OF TRICHOGRAMMA OCCUR IN NORTH AMERICA?

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The chief object of this paper is to call attention to the fact that biological evidence exists which seems to prove that two or more common species of Trichogramma occur in North America. During recent years several investigators have expressed the opinion that all of the described species of Trichogramma belong to one species. The author entertained this opinion until the following observations were made.

For several years he has conducted investigations with the so-called common *Trichogramma minutum* Riley as an egg parasite of the oriental peach month, *Laspeyresia molesta* Busck, and the codling moth, *Carcocapsa pomonella* Linne. During the late fall of 1927 at Moorestown, New Jersey, it was noted that the color of the females, particularly the color of the thorax and abdomen, changed from a light lemon-yellow color (Plate 2, H) to a dark metallic or dingy olivaceous-brown (Plate 2, I). Again in the spring of 1928 the spring brood females and many of the first brood females were dark in color; however, the succeeding generations during the entire summer produced light lemon-yellow females. In the fall of 1928 the yellow females emerging late in October and thereafter changed again to a dark color. The color change in females also took place at Columbus, Ohio, in the fall of 1929 among native Trichogramma collected by Mr. J. R. Stear at Chambersburg, Penna., and Mr. W. P. Flint, at Urbana, Illinois, and sent to the author.

It has been interesting to note that this change in color may be brought about by subjecting the parasitized host eggs to the necessary temperature conditions. This appears to be true, particularly of specimens collected or reared early in the fall. No study has been made to determine the critical temperatures nor the period in the life of the parasite when it is most susceptible to change. Some of the following observations have been made which may throw some light on this problem. If eggs parasitized by yellow females are kept continuously in a warm room (70 degrees F.), they will produce yellow females for an indefinite period, while eggs parasitized by yellow females and subjected to average daily temperatures of 55 to 62 degrees F., or lower, and also to some night temperatures approximating 34 degrees F., or lower, they will produce dark colored females. During the fall of 1929 the author alternated the color of the succeeding generations by subjecting them to the above temperature conditions. Also, differences in color were brought about in the progeny of a given yellow female by subjecting some of the eggs to room temperature and others to low temperatures. During the summer period refrigeration may or may not produce a change in color. In some of the tests where parasitized eggs were placed in a refrigerator immediately after they were parasitized and kept at a temperature below 40 degrees F. most of the females were dark in color.

In May, 1928, it was noted that some of the field collected parasitized oriental peach moth eggs produced females that were distinctly olivaceous-brown in color (Plate 2, I) and closely resembled the dark colored females of the yellow species found late in the fall. These dark colored females were separated from the yellow forms and reared in oriental peach moth eggs. They continued to produce dark females in all succeeding generations during the summer of 1928. Only an occasional collection of parasitized eggs from one orchard produced dark colored females during 1928 while in 1927 no dark colored females had been collected or observed during the summer. In all other collections of field parasitized eggs from many orchards the females that emerged were always yellow.

This unusual appearance of dark colored females during warm weather aroused our curiosity and made us suspect that it might be another species, consequently a series of tests were started to determine this point. A number (50 or more) of cross-breeding tests were conducted between the opposite sexes of the yellow and dark colored forms. Various combinations were tried; single pairs, one female with several males, and many females with many males. In every case where the sexes were from opposite sources no successful copulation was noted and the progeny was always males. Among males and females from a given source copulation occurred readily and the progeny was usually two-thirds females. The author and other investigators have shown that unfertilized females produce males only (arrhenotokous). These results strongly support the statement that there are two species of Trichogramma in New Jersey.

Further evidence which supports the conclusion that there are two species of Trichogramma is the time required to complete a life cycle (egg to adult) of each form under similar conditions. During 1928 from May until late in the fall a careful record was kept of the time required to complete the life cycle of the two daily lots, 25 to 200 individuals of the two forms or species. These studies were conducted in an open screened insectary at Moorestown, New Jersey, and the two lots of parasitized oriental peach moth eggs were kept under identical conditions (side by side in the same container). The details of the methods employed are discussed in a paper[1] now in the hands of the editor of the Journal of Agricultural Research at Washington, D. C. Plate 1 shows conclusively that the average life cycle, of daily lots, of individuals arising from eggs parasitized by dark (D.D.) colored (during the summer) females was a fraction of a day to several days longer than the average life cycle of similar daily lots of individuals arising from eggs parasitized by yellow females (D.Y.). Also from May 25 to October 15 the dark colored females produced ten generations and the yellow females produced eleven generations. It will be noted that the average temperatures occurring during 1928 have been omitted in Plate 1. These are shown in another paper.[1]

Another point of difference in the two forms occurs in their habit of flight. It has been repeatedly noted that the adults of the yellow form may be placed on a piece of paper or upon any open surface and at once they will crawl toward a strong light; however, they will seldom fly or jump any distance. Also, they do not fly readily when they are disturbed or touched with some object. The dark summer form or species, however, has a strong tendency to fly toward the light especially if the adults are disturbed or touched with an object.

Difference in size is not a good character to distinguish the two forms because this is subject to decided variation. Size is determined largely by the amount of food the developing individual has access to in the host egg. For example, an adult produced in egg of the angoumois grain moth, *Sitotroga cerealella* Olivier, is approximately one half as large as an adult produced in the egg (one per egg) of the codling moth, *Carpocapsa pomonella*, or in the egg of a bag worm, *Thyridopteryx ephemeræformis* Haworth.

During the winter of 1928 a careful comparative study was made of the external morphology of the males and females in order to find some good character which might distinguish the two forms or species. Plate 2 shows some of the characters of the wings, genitalia, antennæ and other parts. So far the author has been unable to find any morphological difference in the same sexes of the two forms or species. The characters figured are common to the same or opposite sexes of both forms or species unless stated otherwise in the explanation of the figures. The males resemble each other in color and structure throughout the season while the females resemble each other in structure only, since they differ in color during the summer and again resemble each other in color during late fall and early spring. It appears that we may have in these two forms another instance where morphologically species are alike yet they are distinct for they will not interbreed. Also in this case they differ in their period of development and in their flying habits.

During the summer of 1929 the author continued these studies at Columbus, Ohio. A general questionnaire was sent to several entomologists in the United States and Canada who were

interested in Trichogramma. The questions requested information on the color and habits of the Trichogramma they were investigating. In most every case the response to the questions was generous and also ample living material was sent for examination. It was interesting to note that most of the material received during August produced dark colored females. After further inquiry into the original source of the material it was learned that in most northern points of the United States where dark colored females were being reared or were being produced in numbers for liberation, the original stock came from California or Louisiana. Upon requesting investigators in these places to send living specimens, of native species uncontaminated by shipped in or liberated stock, it was noted that the females were lemon-yellow in color. The information to date indicates that the form or species possessing yellow females during the summer is more common in the north than the form of species possessing dark colored females during the summer. If this proves to be true then we might question the advisability of rearing and using for liberation in northern states a southern form or species which may not be acclimated to northern conditions.

No attempt will be made in this publication to ascertain the correct scientific names for the forms or species under discussion. At the present time living material is being assembled from various sections of North America for the purpose of learning more about the habits and morphology of the species. Perhaps in the future an attempt will be made to straighten out the tangle in the nomenclature that exists, provided some other investigator, better qualified than the author for this sort of work, has not produced a satisfactory solution to the problem in the meantime.

At the present time the author believes we have at least two species in North America even though no morphological differences have been observed. The chief visual difference seems to be in the color of the females during the summer. This color difference may be quite significant, for an examination of the original descriptions of the two species of Trichogramma described by C. V. Riley reveals the fact that in the description of *Trichogramma minuta*[2] the following statements occur: "little

dark colored four winged flies'' and ''it is inconspicuously marked, the body being dark brown with antennæ and legs pale and the wings iridescent''; also in the description of *Trichogramma pretiosa*,[3] he says: ''yellow, the eyes red, the wings hyaline,'' also, ''differs from *Trichogramma minuta* in its smaller size, and uniform pale yellow color.'' Offhand it appears that Riley may have had the same species in Missouri as the author observed in New Jersey; however, it should be noted that Riley's *Trichogramma minuta* material was collected in the fall and it is possible that he may have had the dark colored individuals of the yellow species. For the sake of convenience the author suggests that Riley's original specific names may be used to distinguish the two species discussed in this paper until some investigator makes a thorough study of all species of Trichogramma in North America and elsewhere and gives us an authentic decision on the nomenclature.

Summary

Biological evidence seems to prove that there are at least two distinct species of Trichogramma in North America, Morphologically they are alike; however, during the summer the females of one species are distinctly lemon-yellow in color, while the females of another are dark colored (olivaceous-brown), particularly the abdomen and thorax. The two forms will not interbreed. Also there is a constant difference in the time required for development and in their flight habits. The yellow female species appears to be more common in the north than the dark colored (summer form) females species.

Acknowledgments

The author is indebted to a number of investigators for aid in this investigation, particularly for specimens and answers to questions. He wishes to extend thanks to Messrs. G. J. Haeussler, W. P. Flint, D. W. Jones, Herbert Spencer, W. E. Hinds, S. E. Flanders, J. R. Stear, A. B. Baird and others.

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PLATES I AND II

PLATE 1. The plotted curves show the average number of days required to complete the life cycle of daily lots (25 to 200 individuals per day) of two kinds (species) of Trichogramma reared in eggs of the oriental peach moth during 1928 at Moorestown, New Jersey. The solid line represents the life cycle periods of the species possessing yellow females during warm weather and the dotted line represents the life cycle periods of the species possessing dark colored females during the summer.

PLATE 2. Outline drawings showing some of the external morphological characteristics common to both species unless stated otherwise.

A. dorsal view of a female
B. mesothoracic wing of an adult
C. metathoracic wing of an adult
D. mandible of an adult
E. antenna of a female
F. antenna of a male
G. lateral view of a female
H to K. color pattern; eyes red, light areas yellow (Y), stippled areas on thorax and abdomen olivaceous brown (D)
H. color pattern of yellow female (♀ Y) species
I. Color pattern (in summer) of dark female (♀ D) species, also of late fall and early spring females of yellow species
J. color pattern of male (♂ Y), of yellow female species
K. color pattern of male (♂ D), of dark female species (in summer)
L. lateral view of male genitalia
M. ventral view of male genitalia
N. ventral view of female genitalia
O. lateral view of female genitalia
P. parts of female genitalia.